THE UNIVERSITY OF KANSAS SPACE TECHNOLOGY LABORATORIES

2291 Irving Hill Dr. — Campus West   Lawrence, Kansas 66044

Telephone: 913/864-4775

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CR -129554

KANSAS ENVIRONMENTAL AND RESOURCE STUDY:

A GREAT PLAINS MODEL

Type I Progress Report
for the Period Ending: 30 November 1972

NASA Contract NAS 5-21822
Tasks 1, 2, 3, 4, 5 and 6

Prepared For
Goddard Space Flight Center
Greenbelt, Maryland 20771

Date: April 10, 1973

Reply to
Attn of: 954.01

Subject: NASA Document Discrepancy Report   73-161

To: Mr. E. E. Baker
Deputy General Manager
Informatics TISCO
P.O. Box 33
College Park, Maryland   20740

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APR 24 1973
INFORMATION SERVICE

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NASA SCIENTIFIC
TECHNICAL INFORMATION
FACILITY
TISCO

Re: N 73-13354

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April 23, 1973

Although the above pages were cut in a rather unprofessional manner, no data has been lost from any of the above four pages. Consequently, a new document cannot be provided for this accession.

Sincerely,

John H. Ashley

Phone: 703-321-8517

E. E. Baker
Deputy General Manager

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I

USE OF FEATURE EXTRACTION TECHNIQUES FOR TEXTURE CONTEXT INFORMATION
IN ERTS IMAGERY

R.M. Haralick
Remote Sensing Laboratory
Center for Research, Inc.
Space Technology Center
University of Kansas
Lawrence, Kansas 66044

30 November 1972
Bimonthly Report for Period Ending 30 November 1972

$\mathcal{II}$

BIMONTHLY ERTS-A USER INVESTIGATION REPORT

Type I Progress Report

for the period ending: November 30, 1972

NASA Contract NAS 5-21822

Title of Investigation: Use of Feature Extraction Techniques for
Texture Context Information in ERTS Imagery

ERTS-A Proposal Number: 60-1

Task Number: 1

Co-Investigators: R.M. Haralick and G.L. Kelly

NASA-GSFC PI ID Number: UN 094

Report Prepared by:

K. Shanmugam
K. Sam Shanmugam
Research Associate

Report Approved by:

R. M. Haralick
R. M. Haralick
Co-principal Investigator

III

I. RESEARCH OBJECTIVES

The main objective of this investigation is to study the textural features of selected frames of ERTS imagery and use these areal features along with spectral and temporal characteristics of the resolution cells as the basis for the discrimination between various land use categories.

II. PROBLEMS

Due to the delay in receiving the digital tapes for images of interest in Kansas, the processing of the actual MSS data for textural features could not be initiated until almost the end of this report period. However processing of a set of tapes received towards the end of this report period has been initiated and we do not have any difficulties, at the present time, which will impede the progress of the contract.

III. WORK PERFORMED DURING THIS REPORT PERIOD

The program to extract the textural features of ERTS imagery had been tested on simulated ERTS data using the data retreival program developed by Task 2. Request for digital data corresponding to two frames of Kansas and one of San Francisco Bay area had been put in and one set of tapes for the Kansas Frame had been received on November 24, 1972. The processing of this data set for textural features has already been initiated.

IV. PLANNED WORK FOR THE NEXT REPORT PERIOD

During the next report period, we plan to complete the processing of the Kansas imagery for textural features. We are also planning to process the digital data corresponding to the San Francisco bay area frame. After the textural features for these frames have been obtained, we are planning to conduct several classification experiments to generate land use maps based on the textural features.

V. RELIABILITY EFFORTS

None

VI. SIGNIFICANT RESULTS

None

VII. COST BENEFITS OF SIGNIFICANT RESULTS

None

VIII. PUBLISHED PAPERS, ARTICLES, REPORTS

None

IX. RECOMMENDATIONS REGARDING MAXIMUM UTILIZATION OF ERTS SYSTEM

None

X. CHANGES IN STANDING ORDER FORMS

None

XI. ERTS IMAGE DESCRIPTOR FORMS

None

XII. DATA REQUEST FORMS SUBMITTED

6 October 1972 and 6 November 1972 (Attached)

XIII. FUNDING

Funding is adequate.

XIV. CHANGE IN PERSONNEL

None

ERTS DATA REQUEST FORM
560-213 (7/72)

1. DATE __OCTOBER 6, 1972__

2. USER ID __UN 094__

4. SHIP TO: K. Shanmugam
   [for R. M. Haralick] ☐
   ADDRESS ~~Space Technology Lab~~ NEW
   University of Kansas,
   Lawrence, Kansas 66044

5. TELEPHONE NO. __913-864-3542__ ☐
   or 913-864-4832 ext.35 NEW

6. CATALOGUES DESIRED

   STANDARD ☐ U.S. ☐ NON-U.S.

   DCS ☐

   MICROFILM ☐ U.S. ☐ NON-U.S.

ADDDHHMMS OBSERVATION IDENTIFIER	C CENTER POINT COORDINATES	B SENSOR BAND	P PRODUCT TYPE	F PRODUCT FORMAT	T TICK MARKS	NN NUMBER OF COPIES	A AREA
100616511	3725N 10015W	(4,5,6,7)	D	7 (4 tapes for the 4 strips of the frame)		1	U
100616511	3725N 10015W	6	B	T		2	U
102416511	3725N 10015W	(4,5,6,7)	D	7 (4 tapes for the 4 strips of the frame)		1	U
102416511	3725N 10015W	6	B	T 1-4		2	U

ERTS DATA REQUEST FORM
560-213 (7/72)

1. DATE _____November 6, 1972_____

2. USER ID _____UN 094_____

4. SHIP TO: K. Shanmugam
   [for R. M. Haralick] ☐
   ADDRESS Space Technology Lab
   University of Kansas   NEW
   Lawrence, Kansas   66044

5. TELEPHONE NO. _913-864-3542_ ☐
   or 913-864-4832 ext.35 NEW

6. CATALOGUES DESIRED

   STANDARD   ☐ U.S. ☐ NON-U.S.

   DCS   ☐

   MICROFILM   ☐ U.S. ☐ NON-U.S.

DHHMMS RVATION NTIFIER	C CENTER POINT COORDINATES	B SENSOR BAND	P PRODUCT TYPE	F PRODUCT FORMAT	T TICK MARKS	NN NUMBER OF COPIES	A AREA
18134	37.291 N 120.935 W	(4,5,6,7)	D	7 (4 tapes for the 4 strips of the frame)		1	U
18134	37.291 N 120.935 W	6	B	T		3	U

1-5

INTERPRETATION AND AUTOMATIC IMAGE ENHANCEMENT FACILITY

R.M. Haralick
Remote Sensing Laboratory
Center for Research, Inc.
Space Technology Center
University of Kansas
Lawrence, Kansas 66044

30 November 1972
Bimonthly Report for Period Ending 30 November 1972

2 -

BIMONTHLY ERTS−A USER INVESTIGATION REPORT

Type I Progress Report
for the period ending: November 30, 1972

NASA Contract NAS 5−21822

Title of Investigation: Interpretation and Automatic Image Enhancement Facility
ERTS−A Proposal No.: 60−2
Task Number: 2
Co−Investigators: R.M. Haralick and G.L. Kelly
NASA−GSFC PI ID Number: UN 317

Report Prepared by: K. Sam Shanmugam
                           Research Associate

Report Approved by: R. M. Haralick
                           Co−principal Investigator

2 . a

I. RESEARCH OBJECTIVES

The main objective for the ERTS data processing facility is to provide
the opportunity to use the analog and digital processing available at the University
of Kansas for all ERTS investigators. The work under this task consists of:
1) developing user oriented digital software package for processing digital MSS
data and 2) developing analog/digital package for processing transparencies of ERTS
imagery on the IDECS/PDP-15 facility.

II. PROBLEMS

None

III. WORK PERFORMED DURING THIS REPORT PERIOD

During this report period the development of digital data retrieval programs
have been completed. This package extracts the digital MSS data corresponding to
target areas specified by the user on an MSS image. The user specifies a target
area of interest on the image by specifying the coordinates in millimeters measured
from the left and top edge of the image. The program extracts the digital data for
this target area from the digital tapes supplied by NASA, copies the data onto a
user specified storage media for later processing, computes the mean and variance of
the spectral data in the four MSS bands and also provides a digital picture of the
target area. This package had been successfully tested on the MSS image set
102416511 and is currently being used by other investigators for crop classification
studies.

Two software packages have been added to the IDECS/PDP facility during
this report period. The first package can be used to display and study an equal
probability quantized digital image of an MSS image (transparency). The second
package can be used to obtain textural features of selected areas of an MSS image
using the IDECS/PDP facility. These packages are now being used by various
groups of investigators and the results of their studies will appear in their respective
reports.

IV. PLANNED WORK NEXT REPORT PERIOD

The main thrust of work during the next report period will be directed towards extracting the spectral characteristics of selected fields in the Finney County area in Kansas for which crop type ground truth had been collected. Crop classification algorithms will be developed and tested.

Digital software development will be directed towards implementing boundary enhancement algorithms. The operating personnel in this task will continue to provide user oriented services for ERTS investigators in Kansas.

V. RELIABILITY EFFORTS

None

VI. SIGNIFICANT RESULTS

None

VII. COST BENEFITS OF SIGNIFICANT RESULTS

None

VIII. PUBLISHED PAPERS, ARTICLES, REPORTS

In house memorandum on digital tape accessing procedure is attached.

IX. RECOMMENDATIONS REGARDING MAXIMUM UTILIZATION OF ERTS SYSTEM

None

X. CHANGES IN STANDING ORDER FORMS

None

XI. ERTS IMAGE DESCRIPTOR FORMS

None

XII. DATA REQUEST FORMS SUBMITTED

6 October 1972 and 6 November 1972 (Attached)

XIII. FUNDING

Funding is adequate.

XIV. CHANGE IN PERSONNEL

None

B

ERTS DATA REQUEST FORM
560-213 (7/72)

1. DATE ___OCTOBER 6, 1972___

2. USER ID ___UN 094___

4. SHIP TO: K. Shanmugam
   [for R. M. Haralick] ☐
   ADDRESS ~~Space Technology Lab~~
   University of Kansas   NEW
   Lawrence, Kansas 66044

5. TELEPHONE NO. ___913-864-3542___ ☐
   or 913-864-4832 ext. 35   NEW

6. CATALOGUES DESIRED

   STANDARD   ☐ U.S.   ☐ NON-U.S.

   DCS   ☐

   MICROFILM   ☐ U.S.   ☐ NON-U.S.

DDHHMMS OBSERVATION IDENTIFIER	C CENTER POINT COORDINATES	B SENSOR BAND	P PRODUCT TYPE	F PRODUCT FORMAT	T TICK MARKS	NN NUMBER OF COPIES	A AREA
0616511	3725N 10015W	(4,5,6,7)	D	7 (4 tapes for the 4 strips of the frame)		1	U
00616511	3725N 10015W	6	B	T		2	U
102416511	3725N 10015W	(4,5,6,7)	D	7 (4 tapes for the 4 strips of the frame)		1	U
102416511	3725N 10015W	6	B-4	T		2	U

ERTS DATA REQUEST FORM
550-213 (7/72)

1. DATE ___November 6, 1972___

2. USER ID ___UN 094___

4. SHIP TO: K. Shanmugam
[for R. M. Haralick]
ADDRESS ~~Space Technology Lab~~ NEW
University of Kansas
Lawrence, Kansas 66044

5. TELEPHONE NO. ___913-864-3542___ [NEW]
or 913-864-4832 ext.35

6. CATALOGUES DESIRED

STANDARD [ ] U.S. [ ] NON-U.S.

DCS [ ]

MICROFILM [ ] U.S. [ ] NON-U.S.

DHHMMS RVATION TIFIER	C CENTER POINT COORDINATES	B SENSOR BAND	P PRODUCT TYPE	F PRODUCT FORMAT	T TICK MARKS	NN NUMBER OF COPIES	A AREA
18134	37.291 N 120.935 W	(4,5,6,7)	D	7 (4 tapes for the 4 strips of the frame)		1	U
18134	37.291 N 120.935 W	G	B	T		3	U

2-5

MEMORANDUM

To: CRINC-Supported ERTS Investigation Personnel

From: Donald L. Williams and Sam Shanmagum

Subject: ERTS Digital Tape Access

A procedure for relating the location of an object perceived on an ERTS-1 MSS image to the location of that object on the digital tape has been developed and successfully tested.

The image interpreter specifies the location of the object of interest on the image. The coordinates are expressed in millimeters and are measured from the left and top edges of the image. Because of the slight skew of the image, care must be exercised in reading from the left edge (see Figure 1).

A 2 X 2 millimeter grid has been photographically prepared. This grid is laid directly over the image on a light table. The grid is positioned parallel to the top and bottom edges of the image and even with the left edge on line with the target. The X (horizontal) and Y (Vertical) coordinates are read to the nearest millimeter.

The data retrieval program then extracts the digital data corresponding to a 100 resolution cell by 100 resolution cell (approximately 3 X 4 miles or 5 X 7 Kilometers) area, with the target centered in the middle of this area. The digital MSS data in all four spectral bands or any subset of bands specified by the user are retrieved and output. The digital data is either printed or punched out on cards or written out on a mass storage device such as a tape or disc for later processing. The program also prints out a digital picture of the target area. The program also has the capability of extracting the data corresponding to a field of interest when the coordinates of the upper left hand corner and the lower right hand corner of the field are specified.

The retrieval program has been successfully tested on the image set and digital tape for the image 102416511, which covers a portion of southwestern Kansas.

Figure 1. Lines within the image area indicate the distances to be measured to determine the approximate digital tape location of two points (A and B).

WHEAT: ITS WATER USE, PRODUCTION AND DISEASE DETECTION AND PREDICTION

E.T. Kanemasu
Evapotranspiration Laboratory
Kansas State University
Manhattan, Kansas 66502

30 November 1972
Bimonthly Report for Period Ending 30 November 1972

3 -

BIMONTHLY ERTS-A USER INVESTIGATION
REPORT

TYPE I PROGRESS REPORT
for the period ending: November 30, 1972

NASA CONTRACT NAS5-21822

Title of Investigation: Wheat: It's Water Use, Production and Disease
                          Detection and Prediction

ERTS-A Proposal Number: 060-3

Task Number: 3
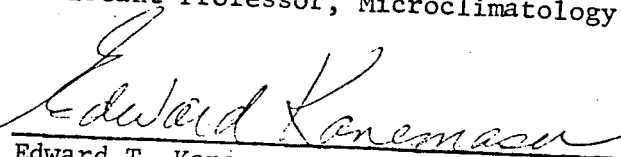
Principal Investigator: Edward T. Kanemasu

NASA-GSFC PI ID Number: UN 661

Report Prepared by: _Edward Kanemasu_____
                    Edward T. Kanemasu
                    Assistant Professor, Microclimatology

Report Approved by: _Edward Kanemasu_____
                    Edward T. Kanemasu
                    Principal Investigator

3-a

I. Summary of research objectives

Objectives of the investigation are: (1) to evaluate the effect of water stress, disease, and leaf area on the reflectance characteristics of wheat, (2) to evaluate disease losses in terms of yield and water use, and (3) to predict disease severity and economic loss.
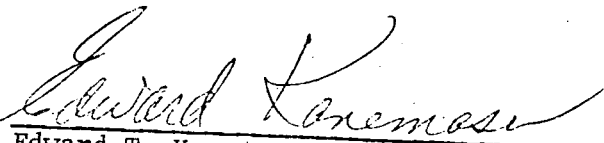
II. Statement of problems

DCP test set has not been received

III. Accomplishments during reporting period

1. Leaf area and soil moisture measurements on tests sites in Finney and Riley Counties.

2. DCP installed in field.

3. Inoculated Riley County test plots

4. Processed 70 mm transparancies of last year's wheat crop taken from low altitude aircraft.

IV. Planned accomplishment during next reporting period

1. Test and run computer program to maximize variation within wheat fields.

2. Process retrospective orders (not yet received) of CCT and 70 mm transparencies on computer and IDEC machine.

3. Print out grey scale map of test area.

V. Efforts to achieve reliability

None. No data on this year's winter wheat crop.

VI. Significant Results

70 mm transparencies of last year's disease wheat fields (prior to ERTS-1) taken from low altitude aircraft has shown that disease severity can be detected from aerial reflectance data.

VII. Estimates of costs benefits

1972 Kansas wheat statistics state that wheat streak and soil borne mosaic caused a loss of $20 and $5 million, respectively.

VIII. List of published articles

None. Short talk on the objectives of our ERTS-1 study will be given at Agricultural Meteorology Conference on January 7, 1973.

IX. Recommended changes in operation

None

X. Changes in standing order form

None

XI. Number of ERTS Image Descriptor Forms

One

XII. List of Data Request Forms

1. 8 November, 1972

2. 10 November, 1972

XIII. Discussion of Adequacy of Funds

None

XIV. Personnel Additions

Ed Chin Choy, research associate, Evapotranspiration Lab.

Melvin Newman, research associate, Plant Pathology

Duane Walker, graduate assistant, Electrical Engineering

John Krupp, graduate assistant, Agricultural Engineering

ERTS IMAGE DESCRIPTOR FORM
(See Instructions on Back)

DATE __November 20, 1972__

PRINCIPAL INVESTIGATOR __E.T. Kanemasu__

GSFC __NAS5-21822__

ORGANIZATION __Kansas State University__

PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS* Cropland	Pasture	Lake	Irrig.	DESCRIPTORS
1021 163334		X			River, City
1021 163335		X			River, City
1023 164514	X		X		Cirrus
1023 164515	X		X		Cirrus
1025 165654	X			X	
1025 165655	X			X	
1057 163344		X			River, City, Cirrus
1057 163335		X			River, City, Cirrus
1058 163904	X	X			City
1058 163905	X	X			City
1058 163924	X	X	X		
1058 163925	X	X	X		
1058 163954	X				Haze City
1058 163955	X				Haze City
1060 165054	X	X			Cirrus
1060 165055	X	X			Cirrus
1061 165124	X			X	Cirrus
1060 165125	X			X	Cirrus
1061 165644	X			X	
1061 165645	X			X	
1061 165704	X			X	
1061 165705	X			X	
1076 163914	X	X			City
1076 163915	X	X			City
1076 163934	X	X	X		Clouds
1076 163935	X	X	X		Clouds

*FOR DESCRIPTORS WHICH WILL OCCUR FREQUENTLY, WRITE THE DESCRIPTOR TERMS IN THESE COLUMN HEADING SPACES NOW AND USE A CHECK (✓) MARK IN THE APPROPRIATE PRODUCT ID LINES. (FOR OTHER DESCRIPTORS, WRITE THE TERM UNDER THE DESCRIPTORS COLUMN).
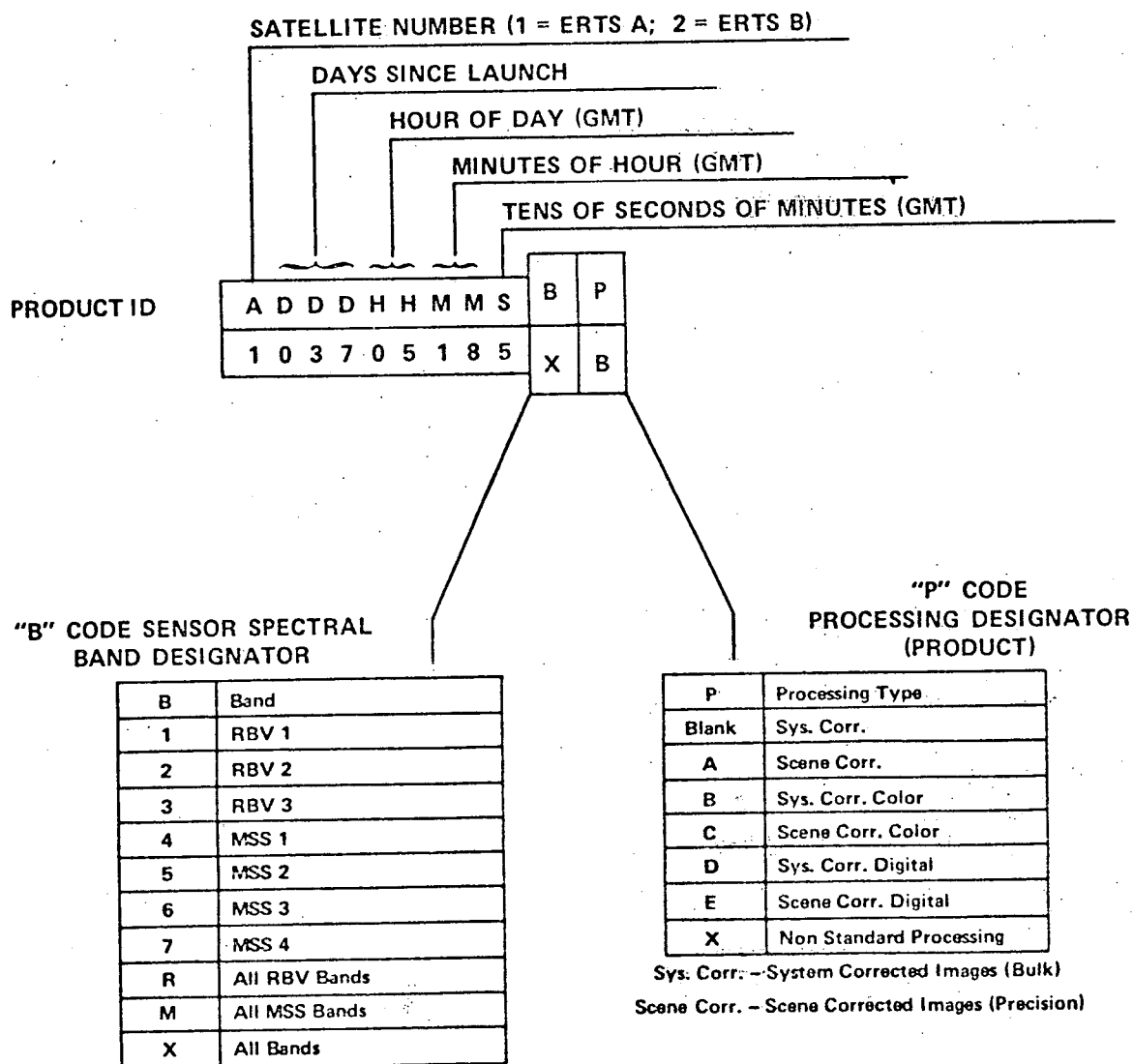
MAIL TO ERTS USER SERVICES
CODE 563
BLDG 23 ROOM E413
NASA GSFC
GREENBELT, MD. 20771
301-982-5406

Image descriptors are only supplied by investigators. An image descriptor is a term which assists in defining the content of an image. All of these inputs will be compiled and entered into the NDPF data base for subsequent investigator query servicing and catalog preparation. A standard vocabulary of image descriptors is included in the Data Users Handbook, Section 4.

Coding for the major portion of this form is straight forward and self explanatory. It should be noted however that it is extremely important to assign the correct product ID to those descriptors that apply to a particular spectral image or a combination of spectral images. Below is a description of the product ID along with tables defining the valid band and product type (processing designator). Your cooperation in providing complete, valid product ID's would be greatly appreciated.

SATELLITE NUMBER (1 = ERTS A; 2 = ERTS B)

DAYS SINCE LAUNCH

HOUR OF DAY (GMT)

MINUTES OF HOUR (GMT)

TENS OF SECONDS OF MINUTES (GMT)

PRODUCT ID

A	D	D	D	H	H	M	M	S	B	P
1	0	3	7	0	5	1	8	5	X	B

"B" CODE SENSOR SPECTRAL BAND DESIGNATOR

B	Band
1	RBV 1
2	RBV 2
3	RBV 3
4	MSS 1
5	MSS 2
6	MSS 3
7	MSS 4
R	All RBV Bands
M	All MSS Bands
X	All Bands

"P" CODE PROCESSING DESIGNATOR (PRODUCT)

P	Processing Type
Blank	Sys. Corr.
A	Scene Corr.
B	Sys. Corr. Color
C	Scene Corr. Color
D	Sys. Corr. Digital
E	Scene Corr. Digital
X	Non Standard Processing

Sys. Corr. – System Corrected Images (Bulk)

Scene Corr. – Scene Corrected Images (Precision)

Data Handling Plan

1. General

Upon receipt of a standing order film (MSS-5, 9.5" positive transparency), the image will be cataloged and inspected visually. Investigators will determine if retrospective orders for the 70 mm MSS bulk and CCT are necessary. The 70 mm transparencies will be processed on the CRES-IDECS machine. The CCT will be processed to determine the location of test area. These data then will be used with a computer program to maximize the variations within the test site and provide training sets for disease detection.

2. Processing

    A. Upon receipt of standing order, the film will be logged, description filed and inspected for the following conditions:

        a. quality of picture (i.e. no telemetry breaks or registration problem) in the vicinity of our test sites,

        b. clouds affecting our test sites and,

        c. observation of test sites.

    B. Investigators will then determine if an ERTS Data Request Form will be submitted for 70 mm bulk transparencies of each MSS band and/or bulk digital tapes of each MSS band.

    C. The 70 mm transparencies will be placed immediately in glass and scheduled for processing on the CRES-IDECS machine to determine the feasibility of various techniques for detecting the total wheat acreages in an image and the condition of such wheat. Specific attention will be drawn to fields in the image which are known to be diseased; then, other fields with similar conditions

will be noted and checked by ground truth personnel.

D. The bulk digital tapes will be processed at KU to consolidate the data within the immediate area of the test field. These consolidated data will be printed out as a gray-scale map for further inspection. When the specific test field and all other wheat fields in the reduced image have been located, each ERTS data point will be given an additional category label. The consolidated set of data will then be run through a computer program which will enhance variations within a desired category and reduce all other points from other categories to zero. The resulting gray-scale map will be inspected to determine if the variation of disease within the field can be detected. These data will then be used as a training set for a pattern classifier to detect a specific disease on other wheat fields in the area.

E. Targets of Opportunity

a. These areas are designated as targets of opportunity because the exact location of disease epidemics cannot be predicted. If an unique opportunity to observe disease or stress is found by field personnel, standing order films on hand and at CRES will be checked to determine if they contain these fields. If they do and adequate 70 mm and digital data exist on hand they will be processed as discussed previously.

b. If existing data is inadequate, we shall obtain proper images and CCT from NASA-GSFC. Proper image identification could be determined through the data bank at Sioux Falls, S.D.

3. Photo Reproduction

   Photo reproduction of the ERTS imagery from GSFC is not anticipated.

4. Data Products

   A. Gray-scale maps of the test sites.

   B. Gray-scale maps of the test sites with maximization variation within field.

   C. Location and identification of wheat fields in test area.

   D. Outline maps of disease area in wheat field.

   E. Wheat disease severity versus reflectance.

   F. Wheat leaf area versus reflectance.

   G. Disease severity versus yield reduction in wheat.

ERTS-1 AGRICULTURAL STATISTICS

Stanley A. Morain
Remote Sensing Laboratory
Center for Research, Inc.
Space Technology Center
University of Kansas
Lawrence, Kansas 66044

30 November 1972
Bimonthly Report for Period Ending 30 November 1972

4 -

BIMONTHLY ERTS-1 USER INVESTIGATION REPORT

Type I Progress Report
for the period ending: 30 November 1972

NASA Contract NAS 5-21822

Title of Investigation: ERTS-1 Agricultural Statistics
ERTS-A Proposal Number: 060-4
Task Number: 4
Principal Investigator: Stanley A. Morain
NASA-GSFC PI ID Number: U664

Report Prepared by: *[signature: Donald L. Williams]*

                          Donald L. Williams
                          Research Assistant

Report Approved by: *[signature: Stanley A. Morain]*

                          Stanley A. Morain
                          Principal Investigator

4: a

I. Summary of research objectives:

The long-term objective of this project is to develop remote sensors, particularly for use at orbital altitudes, as data sources for agricultural statistics. The immediate objectives are to identify wheat fields in Finney County, Kansas, and to make an assessment of acreage and crop vigor. A variety of methods for yield prediction is already employed by agricultural statisticians in government and industry, and the relationship between yield and weather is well established. Based on ERTS data and available weather records, an assessment of the feasibility of predicting yields will be made. This feasibility will be assessed in terms of accuracy and timeliness vis-a-vis present systems. If successful, the project will provide a model for estimating basic crop statistics and crop yields at regional, national and international scales. Under present strategies these data become available long after they are of practical use.

The objectives of this project are closely related to two other ERTS projects: a probabilistic crop type identification study by R.M. Haralick at the Center for Research, Inc., University of Kansas, and a study of wheat disease and pest recognition by E.T. Kanemasu at Kansas State University. Data and techniques developed in these two projects will materially assist in the solution of the agricultural statistics project.

II. Statement or explanation of problems impeding progress of investigation (i.e., explanation of any nonconformance with work schedule).

We have not yet specifically begun our analysis of winter wheat because we have not yet received coverage after the wheat had begun to grow significantly. However, we envision no difficulty in accomplishing our research as outlined in our Data Handling Plan. We further believe that the experience gained in our analyses to date will facilitate interpretation of wheat when suitable imagery arrives.

III. Discussion of accomplishments or work performed during reporting period:

Preliminary work for the creation of a set of land systems has been completed. Land systems are a regional description technique which synthesize elements of the landscape to define regions which are relatively homogeneous or have readily accountable internal variation. The component data which we are using for the land systems in Finney County are land use (Figure 1), climate, geology, geomorphology, ground water, soil type, and natural vegetation.

On 6 and 7 October 1972, Mr. Williams, with the assistance of Mr. Crane (staff, RSL, CRINC), collected surface observations in Finney County and a small-adjacent area of Hodgeman County (Figure 2). The objective of the collection was to supply a large data base of crop types. The team collected crop type and land use data for 957 fields, approximately ten percent of the surface area of Finney County. The collection areas were selected to provide data for each land use region in the county (Table 1). These areas were also designed to be easy to locate with respect to landmarks on the ERTS-1 imagery and to be easily reproducible next spring.

Mr. Williams and Ms. Barker have recently completed and submitted a report entitled "Center Pivot Irrigation in Finney County, Kansas: An ERTS-1 Interpretation Procedure." This report details an interpretation technique by which an important agricultural statistic may be extracted from ERTS-1 imagery.

We have prepared and submitted a Data Handling Plan which outlines our research plan for the remaining period of this project in detail.

IV. Discussion of planned accomplishments or work during next reporting period:

We plan to complete the land system description. We plan to map winter wheat from the imagery and to test various techniques for acreage determination (see Appendix A). Having just received the first digital tapes (for August 16, 1972), we shall test our point location scheme and investigate discrimination among crops on that date.

V. Discussion of efforts to achieve reliability:

We have devised an acreage measurement test procedure in which four techniques will be employed (see Appendix A). Results of each technique will be compared to the surface observations and to medium scale aerial photographs taken on 2 June 1972.

In our human interpretations, we employ a team approach. One interpreter analyzes the image. Then a second interpreter checks the work. Results are then checked against the surface observations and available aerial photography to determine the magnitude and causes of errors.

VI. Discussion of significant results and relationship to practical applications or operational problems:

The work on center pivot irrigation demonstrates that agricultural statistics may be derived from ERTS-1 imagery. These are statistics which are not readily available from other sources.

VII. Discussion and estimates of the cost benefits of any significant results:

No estimates have been made as we have only recently completed and not yet disseminated the center pivot irrigation paper.

The Center for Research, Inc. is organizing a user seminar which will focus on the use of remote sensor data in agriculture. Two of the topics to be explored are the use of satellite imagery and benefits derivable from remote sensor data. We expect results of this seminar to contribute to future cost-benefit analyses.

VIII. List of published articles, papers, pre-prints, in-house reports, abstracts of talks that were released during the reporting period after receiving notice of compliance with the provisions of Article IX of the contract:

None, pending release of center pivot irrigation paper.

IX. Recommendations concerning practical changes in operations, additional investigative effort, correlation of effort and/or results as to maximum utilization of the ERTS system:

None.

X. List by date of any changes in standing order forms:

Change, submitted 9/18/72, from bands 2,5,7 to bands 4,5,7 for the same area. Notification of change has been received.

XI. Number of ERTS Image Descriptor Forms (Attachment B) as required by Article VII of the contract:

One ERTS Image Descriptor Form was submitted with the center pivot irrigation report.

XII. List (by date) of any Data Request Forms (for retrospective data) submitted to NASA-GSFC/NDPF during the reporting period:

A request for one color composite image of Finney County was submitted 9/18/72. The image has not been received.

XIII Discussion of adequacy of funds to complete task:

All funds are presently adequate. However, funds for travel for projected field data collection may be inadequate before the end of the contract period.

XIV. Description of any significant changes in operating personnel during the reporting period or anticipated during the next reporting period:

No changes have occurred and none are expected.

Table 1. Crop Types Sampled on 6 and 7 October 1972, Finney County, Kansas. Land Use Regions As Shown in Figure 1.

Land Use Regions

Crop	1[1]	2[2]	3	4	5	6	Total
Wheat	32	80	62	81	32	21	308
Wheat Stubble	22	55	36	32	0	7	152
Volunteer Wheat	3	9	10	17	1	7	47
Corn	2	4	9	52	53	7	127
Grain Sorghum	2	16	15	60	10	6	109
Alfalfa	1	6	9	66	4	1	87
Pasture	13	9	2[3]	5	2[3]	4	35[3]
Weeds	8	15	7	0	1	1	32
Bare Ground	0	6	0	14	0	0	20
Forage Sorghum	1	6	3	2	5	1	18
Sugar Beets	0	0	0	15	0	0	15
Cultural	0	0	3	1	0	0	4
Sudan	0	1	0	0	0	0	1
Brome	0	0	0	1	0	0	1
Water	0	0	0	1	0	0	1
Total	84	207	156	347	108	55	957

1 Includes 26 fields in Hodgeman County
2 Includes 24 fields in Hodgeman County
3 Does not include extensive areas of rangeland occurring in these regions

APPENDIX A

Calculation of area from ERTS-1 data can be approached in several ways, each of which contains error terms. The techniques to be used in this project are outlined below in terms of error and cost factors.

1. Electronic image enhancer (IDECS): the remote sensing team at Kansas University has developed an electronic image analyzer. This device consists of several electronic units linked to a PDP 15 computer, an IBM 7094 computer, and to both color and black and white TV displays. It has a wide range of capabilities, including color combining, density slicing, area integrating, and spectral analyzing. Of specific interest in this project is the area integrating capability.

For area calculations, a framing device is first positioned over a known site (in this case, a known wheat field or other crop type). The area within the frame is then density sliced, constituting in effect a "training" area. After training on this site, the entire scene within the raster or vidicon field-of-view is "predicted." The proportion of enhanced area to total area in the field-of-view is calculated and converted to acres. In this work, the field-of-view will be masked to coincide with previously established land use regions.

Sources of error include those of omission and commission. These can be accounted for in part by comparing results with data derived by other means. More importantly, we feel, are the limitations imposed by resolution of the TV display units. ERTS imagery can be enlarged to overcome some of this difficulty, but we suspect that the sizes of very small fields that are visually detectable will be distorted on the enhanced images. Cost will also be a concern. The IDECS system now costs $35/hour plus the operator and research salaries. In view of limitations on the reliability of results from this system, we propose to employ it in a research capacity and to compare results from this system to those obtained by other means. We know from our radar work on Finney County that on coarse resolution radar imagery, the IDECS system can give repeatable results to within $\pm 5\%$ of the known value.

2. Hewlett-Packard programmable calculator. The remote sensing laboratory obtained an HP calculator specifically for spatial analysis. Our model has a plotting

board with tracing unit. Signals from the tracer can be recorded and stored in the calculator, which, in turn, can be programmed to compute acreages. The process would involve tracing the outlines (or plotting the corners) or individual fields, converting the data to acres and summing.

The main source of error in this technique lies in the accuracy of tracing or corner plotting. Even if the imagery is enlarged many times, there may be considerable accumulated error, much of which will be attributable to manual sources. Cost-wise, this technique will require only manual labor and the normal operating cost of the calculator. We would anticipate the results to be more reliable and cost less than those obtained by IDECS, but to take longer to acquire. By comparing the time, operating costs and quality of results, we can better evaluate the merits of these approaches.

3. MSS data tape: A third technique for calculating wheat acreage in Finney County will involve the MSS (band 5) data tape. In this case, we intend to produce a map print-out on which we can locate each wheat field. By locating the coordinates, we can convert the axes to linear distances and compute the acreage. We should be able to locate fields rather easily using the red band as explained in the text of this plan.

The main source of error will lie in the cells bordering a given field. Since each cell represents a linear distance of approximately 200 feet, a miscalculation of one resolution cell circumscribing a 160 acre field amounts to an error of $\pm 33\%$ ($\pm 16\%$ on a 640 acre field). This same error applies to all the techniques discussed here. The advantage of using computer maps to estimate the acreage is that the errors associated with items 1 and 2 are reduced or eliminated. The cost involved, once the maps are produced, is entirely manual labor. However, the results may be the most reliable of any obtained and will form a base-point for comparison with those from approaches 1 and 2.

4. Transparent template: Perhaps the least sophisticated, yet potentially most reliable, means for calculating crop acreage from either imagery or computer map is to construct a template of common field sizes. We believe that under high contrast conditions (winter season?) the smallest field visible on the red band is 20 acres. Other common field sizes are 40, 80, 160 and 320 acres, an artifact of the township and range system of land survey. Because of this, we can construct a transparent overlay at a given scale (1:1,000,000; 1:500,000; 1:250,000, etc.) and simply match fields to template sizes.

The error in this technique is perhaps least of all those discussed when viewed in the aggregate. Actual acreages are not calculated; instead, field sizes are assigned on the basis of "best fit." In other words, a 35 acre field, as calculated by methods 1, 2 or 3 above, would simply be called 40 acres. For individual counties, interpreters with modest experience should be able to estimate a given crop's acreage rather quickly by this technique. We will employ it in an effort to evaluate its accuracy and reliability with respect to other techniques.

APPLICATION OF ERTS DATA TO KANSAS AGRICULTURE

(Agricultural Statistics from Finney County)

NAS 5-21822   MMC #060-IV

DATA HANDLING PLAN

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Donald L. Williams (R.A.)

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November 1972

ERTS-1 DATA HANDLING PLAN
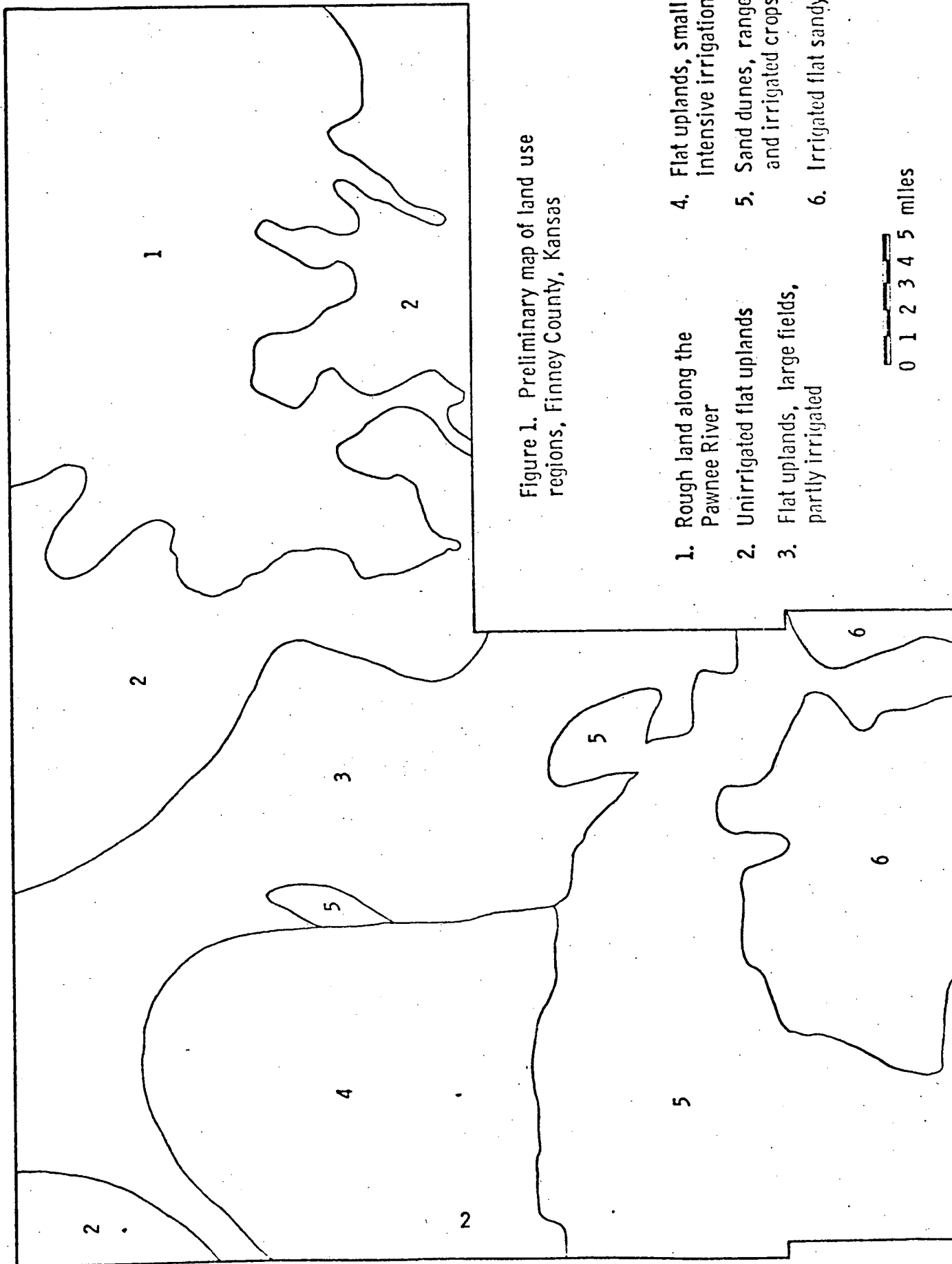## Agricultural Statistics for Finney County, Kansas

INTRODUCTION

As outlined in the work statement, the objectives of this research are three: the first involves determination of wheat acreage, of wheat winter survival, wheat harvested, etc. as far as they may be determined using ERTS-1 MSS data; the second requires the addition of results from objective number one to meteorological data obtained from a network of ground stations to estimate wheat yields in Finney County, Kansas. A third objective focuses on the sampling strategy required to obtain agricultural crop statistics. The last of these objectives is a significant adjunct to the first two but is distinct from them. Since the ERTS-1 satellite passes overhead only once in 18 days, a sampling strategy is needed that is independent of variable cloud cover. Although the major emphasis in this research will be placed on winter wheat (divided into irrigated and non-irrigated types), it will be necessary to work with other crop types to achieve the desired results. The first two objectives will be approached using a combination of the spectral and temporal concepts. Basically the plan calls for a determination of the spectral responses of wheat as a function of growing stage and a comparison of those spectral responses, through time.

DATA HANDLING PLAN

The data handling plan for this research will follow the model proposed by Steiner (1970). He has proposed a five step program for conducting temporal crop surveys from space. First the study area will be regionalized on the basis of land use. A first attempt at defining these regions in Finney County is shown in Figure 1. Within each area transects will be selected for sampling, mapping and periodic ground observation. The third and fourth steps require repeated coverage by the appropriate sensors. When a complete temporal data set becomes available,

4-10

Figure 1. Preliminary map of land use regions, Finney County, Kansas

1. Rough land along the Pawnee River
2. Unirrigated flat uplands
3. Flat uplands, large fields, partly irrigated
4. Flat uplands, small fields, intensive irrigation
5. Sand dunes, rangeland and irrigated crops
6. Irrigated flat sandy soils

0 1 2 3 4 5 miles

reflectances can be compared, combined with weighting functions to account for the crop mix in the particular study area, and interpreted for crop type and for other information. One of our ultimate goals is to link the temporal data set to known crop phenologies. Though Steiner's model is sketchy in most details, it is a useful beginning point for the present research. Specifically, for acreage estimates (a vital part of objective number two) we propose a four point data handling plan.

1. During the winter months of mid-December through mid-March, the dominant visible crop in Finney County is winter wheat. At this time of year, fields should be easy to image, locate and identify on the red band of ERTS-1 imagery. We intend to review the temporal sequence of this band throughout this time frame for purposes of selecting an optimum, nearly cloud-free image, showing the distribution of wheat fields in the study area, then to order the magnetic tape for all four bands. Our object in this stage is simply to locate wheat fields and calculate total acreage as observed on the image. To support the interpretation of this particular image we have already collected (during the fall months of 1972) necessary ground truth for wheat fields within each of the subregions delineated in Finney County (see discussion of objective three below and Figure 2). Measurement of acreages will be performed by several techniques to compare results, and these results will then be compared with county data obtained from ASCS offices. Specifically, we will employ a Hewlett Packard programmable calculator for plotting the wheat coverage and we will compare these results with those obtained from both the IDECS area integrator and data tape analysis (see Appendix A). The results will constitute the first data points in both the time and spectral data spaces against which later changes can be compared. Spectral data of all main crops will be extracted from the MSS data tape and utilized in the creation of spectral identification curves (see NAS 5-21822, Task 60-1 for details).

2. During the time frame from March to April the agricultural scene in Western Kansas begins to renew spring growth. At this time we will select a second image for calculation of winter survival in wheat. Each year a certain percentage of wheat planted the previous fall is plowed under or otherwise destroyed. Moreover, it is a growing practice in the winter wheat belt to utilize wheat fields for winter grazing with no intention of harvesting for grain. These acres must be subtracted from the total wheat acreage planted before any accurate projection of yield can be made. During the month of April ground truth will again be collected to estimate
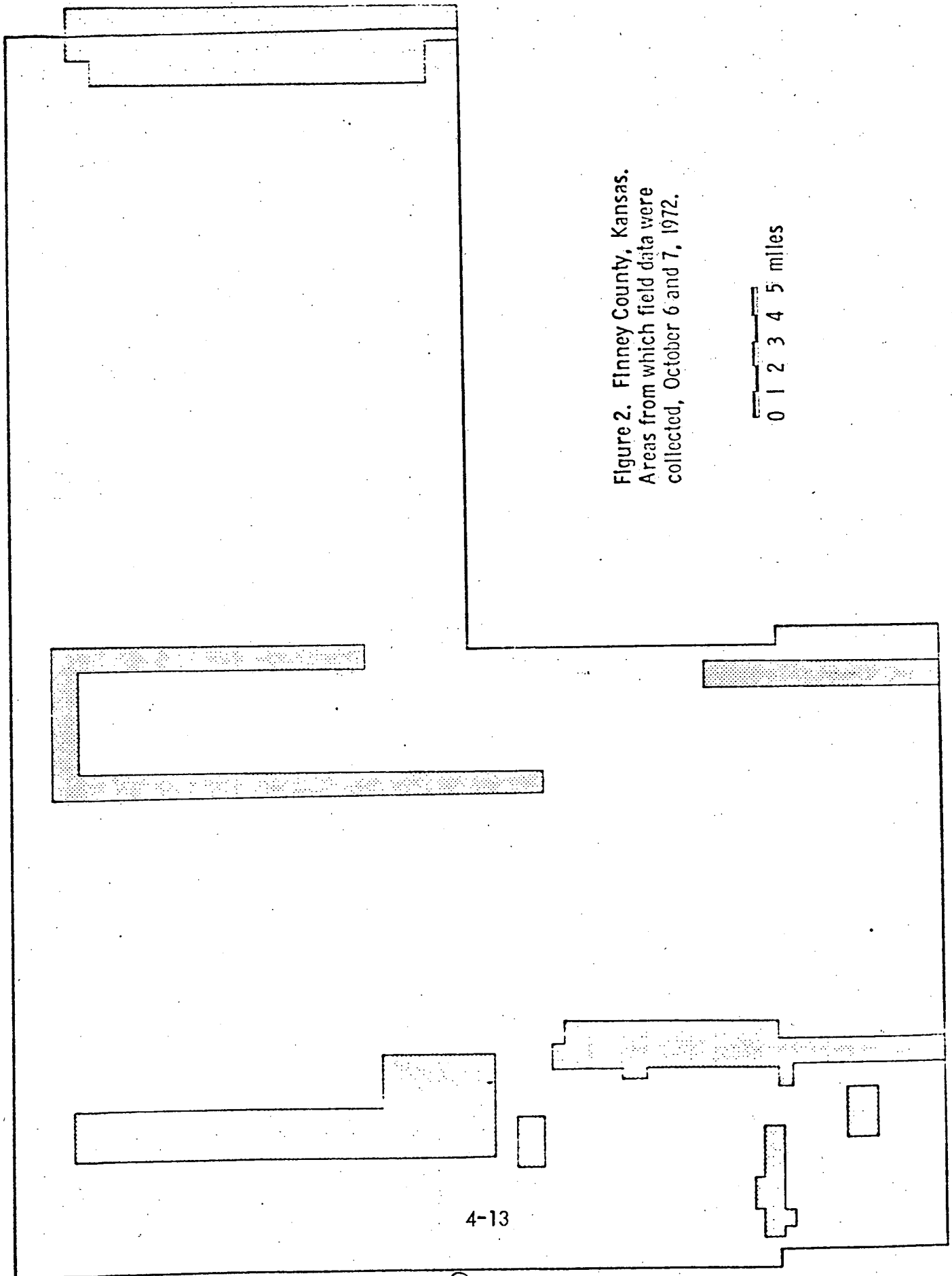
4-12

Figure 2. Finney County, Kansas. Areas from which field data were collected, October 6 and 7, 1972.

0 1 2 3 4 5 miles

the crop mix for wheat pasture and alfalfa since it will be necessary to compare their respective spectral responses early in the growing season. Alfalfa and pasture are perennial crops. Images from the preceding September will be compared to the April images to find fields with no significant spectral change; which, in this study area will be either alfalfa or pasture. We will compare the results of the ground truth with published past records of alfalfa and pasture acreages in Finney County so that we can apply proper weighting functions to the estimated wheat acreage in April. We should be able to locate those particular wheat fields that have been plowed under by comparing the April spectral response to that derived from step one above. Examination of imagery received to date shows that this can be done without difficulty.

Also during the early spring period we will begin to compile weather data for the 1973 growing season. These will include temperature and precipitation data for a network of stations in, and surrounding, Finney County (see discussion of yield prediction below for details). As a refinement on the relationship between weather data and wheat spectral responses we will attempt, where possible, to compile information on wheat varieties to see if there is any significant spectral variation between them. This latter task may be quite difficult, as we have already discovered that few data on wheat varieties are routinely gathered by any of the USDA county or state agencies.

3. During the months of May and June the winter wheat crop is developing and maturing rapidly. We will select from this time frame as many MSS images as appropriate for filling out the data on spectral identification curves. By this time in the growing season we will have already determined the location of wheat fields, the acreage of wheat, the appearance of these fields on a regional basis within Finney County, and the spectral response and location of its nearest spectral neighbors, alfalfa and natural pasture. In addition to these data we will have our first opportunity to obtain spectral responses for other crops in Finney County; namely, corn and sorghum (Appendix B).

4. Calculation of wheat acreage harvested represents a problem of the first order. We expect that the spectral response for ripe and harvested wheat (i.e. wheat vs. wheat stubble) will be very similar and that difficulty will be encountered in distinguishing cut from uncut fields. Research will be conducted to evaluate this problem. In the meantime we will assume that all wheat acreage that reaches maturity will be harvested and base our yield estimates on that quantity. Obvious crop losses that occur between maturity and harvest will be accounted for.

This will be done for each land use region previously defined, within the county. Also from the June-July imagery we will have a second look at other crop types in Finney County and begin to create spectral identification curves for them as well. We will use data beginning July 1972 to aid in the construction of these curves.

Having compiled the acreage estimates and spectral responses through time for irrigated and non-irrigated wheat (as well as for alfalfa, pasture, corn and sorghum), it is necessary to introduce weather history data in order to make actual yield predictions. Thompson (1969) has already computed the relationship between weather history and wheat yield in western Kansas (Appendix C). We know from his study that there is a very high correlation between spring weather conditions and June harvest. We will collect the necessary weather data from a network of stations and, using a regression equation derived from Thompson's attributes, compute the estimated yield per acre in Finney County. Total county yield will then be the product of yield per acre times number of acres as computed from the ERTS-1 imagery. It is our intention to complete these calculations by the end of July after receipt of suitable imagery from the June-July overpass. If successful, this estimate will pre-date the usual announcement of Finney County wheat yield by several weeks or months.

The third objective of this research is to design a sampling strategy that is usable independently of the instantaneous cloud cover. Agricultural surveys from space, based on the present 18 day overpass must be so arranged that the necessary data can be extracted from imagery regardless of the cloud patterns at the instant of over-pass. Some previous agricultural surveys, conducted using aircraft sensors, have shown the inadvisability of sampling strategies tied to specific fields. Cloud covered sample sites cannot be used in data analysis; consequently for this research a sampling design has been formulated to relieve that situation.

The strategy we have adopted involves the concept of land systems as defined by Christian and Stewart (1953). The land system is conceptually no different from the model proposed by Steiner (1970) and can be used in the same way for the present purpose. It is assumed for present purposes that these regions are homogeneous environmentally as well as in terms of farming practices. For each region it is possible to calculate: (a) the proportion of the entire county occupied by this region; (b) the proportion of the area within each region devoted to each particular crop; and (c) the proportion of any given crop existing in a given state of growth. Essential to the design of this sampling strategy is the need to image the entire area

at least once by ERTS-1 (or alternatively to have the exact location of each field plotted from ground truth at some point in the early stages of the growing season). If we know the proportion of county land occupied by a given region and the proportion of land within that region devoted to a particular crop, then we can, on any given cloudy day, estimate from the proportion of visible to non-visible region, the corresponding proportion of crop in a given crop state. Within each region in the county sufficient ground truth sampling must be on hand in order to determine the time dependent spectral response of any given crop in various stages of growth. For this particular project we will have acquired complete data on wheat in Finney County during the winter months from December through February. Our intention during the coming months is to formalize this model and test it during the Spring of 1973.

REFERENCES

Christian, C. S., and G. A. Stewart, 1953, General Report on Survey of Katherin-Darwin region, 1946, CSIRO Australia, Land Research Series #1.

Steiner, D., 1970, "Time Dimension for Crop Surveys from Space," Photogrammetric Engineering, vol. 36, no. 2, pp. 187-194.

Thompson, L. M., 1969, "Weather and Technology in the Production of Wheat in the United States," Journal of Soil and Water Conservation, vol. 24, no. 6, pp. 219-224.

APPENDIX A

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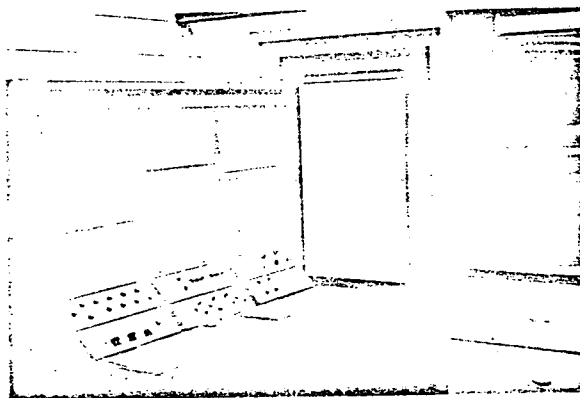

Figure 3.

For area calculations a framing device is first positioned over a known site (in this case a known wheat field or other crop type). The area within the frame is then density sliced, constituting in effect a "training" area. After training on this site the entire scene within the raster or vidicon field-of-view is "predicted". The proportion of enhanced area to total area in the field-of-view is calculated and converted to acres. In this work, the field-of-view will be masked to coincide with previously established land use regions.

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APPENDIX B

Identification of crops with essentially identical growing seasons may be difficult from MSS data. One possible solution, which we intend to test on the Finney County data, is outlined in this appendix. This solution will not produce crop identification for specific fields, but will yield aggregate statistics. The technique will be operated within the regions defined for this report and will be based on a ground data sample within each region. An important element of the technique is that spectral signature separation of crops is not required.

To implement the procedure, a vector of measurements will be developed for each field in the ground data sample. These measurements may be developed either from the images or the digital tapes. Preliminary analysis of available images suggests vector lengths of 3 to 8 measurements may give usable results. All identical vectors will be tabluated and the empirical probability of a given crop type being associated with that vector will be calculated.

The vector for all fields are then calculated. Crop types are then assigned according to the probabilities associated with each vector. The resulting data are summarized for the county. The result is the total area in each crop in the county.

This method is readily amenable to automatic processing from the digital tapes, should it prove a satisfactory method for obtaining statistics for aggregate units.

Time trends were developed using dummy variables. Variable one had numerals 1 to 25 for the years 1920 to 1944. All years from 1945 to 1968 had the numeral 26 in the column for variable one. Variable two had the numeral 1 for all years from 1920 to 1945. The years from 1946 to 1968 had numerals 2 to 24 in the column for the second variable. In other words, 1946 had the numeral 2 and 1968 had the numeral 24 in the column for the second variable. The third variable was the square of all numerals in the second variable. The numeral 1 appeared in all years from 1920 to 1945. The numeral 4 appeared in 1946, and 576 appeared in 1968 for the third variable.

The first multiple regression analysis in this study included the weather variables in linear and quadratic form plus all three variables for time trend (Table 2). Time trends in three states indicated a linear uptrend in yield after 1945 — North Dakota, South Dakota, and Kansas. The analysis was run again for these states without the third variable, thus giving two linear time trends.

Time trends for Oklahoma, Illinois, and Indiana were linear from 1920 to 1945 and curvilinear from 1945 to 1968.

The curve for each weather variable in each state was plotted graphically from the regression equation. If the curve was a convex parabola, the variable was assumed to be curvilinear for further analysis. If the curve was a concave parabola, the variable was treated as a linear relationship in further analysis. The rationale here is that one would expect an optimum temperature or optimum amount of rainfall. As the weather variable departs from optimum, the yield should decline. A concave curve indicates high yields with extreme departures from normal rainfall or normal temperature in either direction and would be illogical in regression analysis.

Summary

Wheat yields started climbing rapidly in the United States after 1945. The use of fertilizer, particularly nitrogen, appears to be the major factor in this trend change.

Wheat yields increased at an average annual rate of about a half bushel per acre per year in North Dakota, South Dakota, and Kansas from 1945 to 1968. The annual yield increase was nearly a bushel per acre in Illinois and Indiana around 1950, but was increasing at a rate of more nearly a half bushel per acre per year by 1968. The trend in yield increase for Oklahoma was almost a bushel per acre per year around 1950, but by 1968 the annual rate of increase was very slight.

In the spring wheat states of North and South Dakota wheat responds favorably to above normal rainfall throughout the year, above normal temperatures early in the growing season, and below normal temperatures late in the growing season.

Hard red winter wheat in Kansas and Oklahoma responds in particular to above normal precipitation in the fall and winter and again in April. Cooler than normal temperatures in the spring until the crop is mature are also favorable.

Soft red winter wheat in Illinois and Indiana appears to benefit from less than normal rainfall throughout the year, near normal temperature in April, and cooler than normal temperatures in May and June.

The weather variables and technology trends accounted for 80 to 92 percent of the wheat yield variability in the six states.

Because the major wheat belts of the world occur at about the same latitude, where weather is somewhat similar, there is a correlation between wheat production in the United States and the rest of the world.

Table 2. Regression coefficients and "a" values for multiple regression analysis of wheat yields.

|		North Dakota	South Dakota	Kansas	Oklahoma	Illinois	Indiana
"a" Value		10.113	11.789	12.215	13.198	15.893	13.488
Trend 1920–45	Linear	.045	−.052	.066	.021	.158	.217
Trend 1945-68	Linear	.572	.442	.498	.981	.902	.933
	Quadratic	—	—	—	−.021	−.005	−.008
August-March Precipitation	Linear	.926	.416	.631	.380	−.221	−.229
	Quadratic	−.021	−.179	—	−.027	−.001	—
April Precipitation	Linear	.426	1.568	.223	.186	.161	−.141
	Quadratic	.018	−.614	−.048	−.048	−.249	—
April Temperature	Linear	.096	.225	−.095	−.321	−.057	.015
	Quadratic	−.028	−.045	—	—	−.013	−.022
May Precipitation	Linear	.900	−.158	.191	−.618	−.549	−.317
	Quadratic	−.061	.132	−.285	−.120	−.077	−.072
May Temperature	Linear	.107	−.057	−.223	−.315	−.293	−.397
	Quadratic	—	—	—	−.059	—	.013
June Precipitation	Linear	.701	.433	−.327	.111	−1.339	−.730
	Quadratic	—	—	—	−.235	−.228	—
June Temperature	Linear	−.417	−.303	−.101	.392	−.351	−.121
	Quadratic	—	—	−.005	−.163	—	—
July Precipitation	Linear	.381	−.961	—	—	—	—
	Quadratic	—	.008	—	—	—	—
July Temperature	Linear	−.214	−.431	—	—	—	—
	Quadratic	—	—	—	—	—	—
Standard error in bu./a.		2.9	2.4	2.5	2.8	2.8	3.1
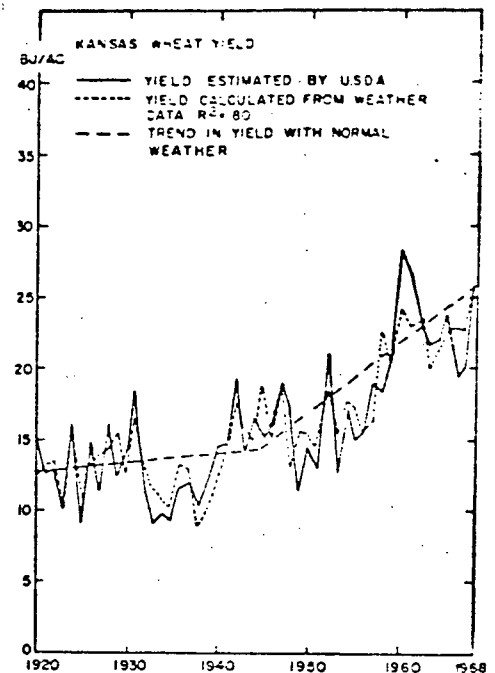
Figure 6. Actual and calculated yields and trend in yields of wheat in Kansas.

Kansas and Oklahoma

Figures 6 and 7 show the results of the multipe regression analysis for Kansas and Oklahoma. Wheat yields with normal weather were about equal in the two states in 1945 and again in 1968. However, the technology trend was curvilinear for Oklahoma and linear for Kansas. Extrapolation of the trends with normal weather indicated a further gain of a half bushel per acre per year in Kansas but a leveling of yields for Oklahoma. About 40 pounds of nitrogen per acre were used in the two states in 1968.

There is no apparent explanation of why the yield trend with normal weather is curvilinear for Oklahoma and so much steeper than the trend for Kansas from 1945 to 1960. Kansas was using more fertilizer on wheat than Oklahoma prior to 1960. One possible explanation is that normal weather in Kansas is more favorable for wheat than is normal weather in Oklahoma. Given the same tech-

nology, one would expect yields to reach a higher level in Kansas.

Highest wheat yields in Oklahoma and Kansas are associated with above normal precipitation from August through March. Normal precipitation in this period is about 13 inches in Kansas and 18 inches in Oklahoma. The relationship of this variable to wheat yield is linear for Kansas (with a regression coefficient of .63) and indicates a gain of .63 bushel of wheat for each additional inch of above normal fall and winter precipitation.

Highest wheat yields in Kansas are associated with above normal rainfall in April, normal rainfall in May, and below normal rainfall in June. Normal amounts of rainfall are 2.51, 3.74, and 4.22 inches, respectively, for April, May, and June. Peak rainfall in June appears to be somewhat excessive for wheat in most years in Kansas.
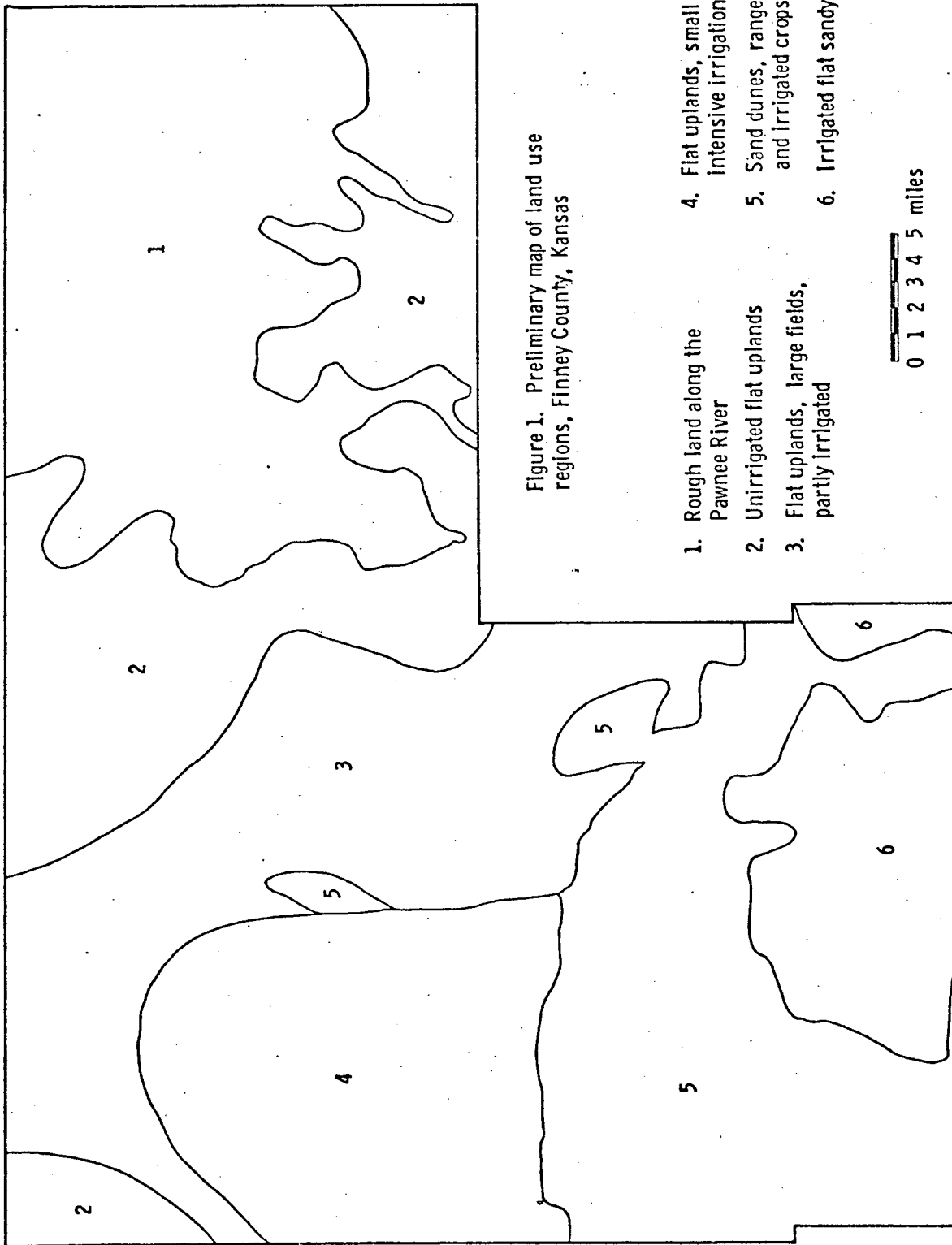
Highest wheat yields in Oklahoma are associated with above normal rainfall in April, below normal rainfall in May, and normal rainfall in June. Normal amounts of rainfall are 3.48, 4.76, and 4.06 inches, respectively, for April, May, and June. The rainfall peak in May appears to be somewhat excessive for wheat in most years in Oklahoma.

Below normal temperatures in

April, May, and June are associated with highest wheat yields in Kansas. Highest wheat yields in Oklahoma are associated with below normal temperatures in April and May, but slightly above normal temperature is desirable after the wheat is mature and ripening. Just before maturity, however, lower than normal temperature is desirable in both states.

The year 1960 was unusually favorable for wheat in Kansas. Fall and winter precipitation was much higher than normal. April rainfall was slightly below normal, but April temperature was slightly above normal. May rainfall was slightly below normal, and May temperature was about normal. June rainfall was only slightly below normal, and June temperature was slightly below normal. The only significant departure from normal among the weather variables was the fall and winter precipitation.

The years with the lowest wheat yields in Kansas were 1933 and 1953 when precipitation was well below normal in the period August through March, in April, and again in June.

Figure 1. Preliminary map of land use regions, Finney County, Kansas

1. Rough land along the Pawnee River
2. Unirrigated flat uplands
3. Flat uplands, large fields, partly irrigated
4. Flat uplands, small fields, intensive irrigation
5. Sand dunes, rangeland and irrigated crops
6. Irrigated flat sandy soils
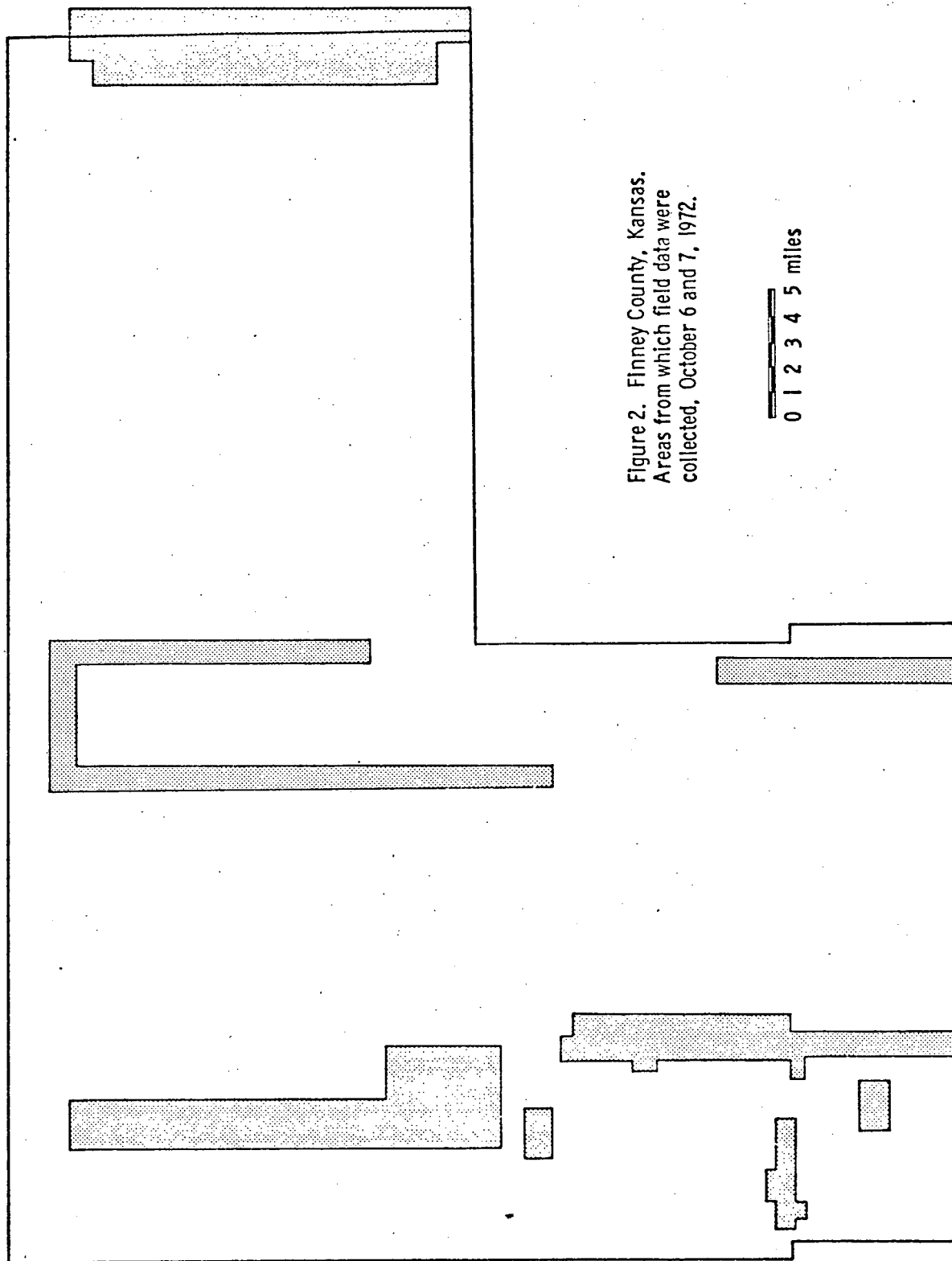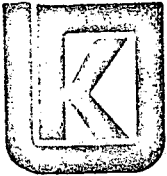
0 1 2 3 4 5 miles

4-23

Figure 2. Finney County, Kansas. Areas from which field data were collected, October 6 and 7, 1972.

0 1 2 3 4 5 miles

THE UNIVERSITY OF KANSAS SPACE TECHNOLOGY LABORATORIES

2291 Irving Hill Dr.— Campus West   Lawrence, Kansas 66044

Telephone:

. MEMORANDUM

To: CRINC-Supported ERTS Investigation Personnel

From: Donald L. Williams and Sam Shanmugam

Subject: ERTS Digital Tape Access

A procedure for relating the location of an object perceived on an ERTS-1 MSS image to the location of that object on the digital tape has been developed and successfully tested.

The image interpreter specifies the location of the object of interest on the image. The coordinates are expressed in millimeters and are measured from the left and top edges of the image. Because of the slight skew of the image, care must be exercised in reading from the left edge (see Figure1).

A 2 X 2 millimeter grid has been photographically prepared. This grid is laid directly over the image on a light table. The grid is positioned parallel to the top and bottom edges of the image and even with the left edge on line with the target. The X (horizontal) and Y (Vertical) coordinates are read to the nearest millimeter.

The data retrieval program then extracts the digital data corresponding to a 100 resolution cell by 100 resolution cell (approximately 3 X 4 miles or 5 X 7 Kilometers) area, with the target centered in the middle of this area. The digital MSS data in all four spectral bands or any subset of bands specified by the user are retrieved and output. The digital data is either printed or punched out on cards or written out on a mass storage device such as a tape or disc for later processing. The program also prints out a digital picture of the target area. The program also has the capability of extracting the data corresponding to a field of interest when the coordinates of the upper left hand corner and the lower right hand corner of the field are specified.

The retrieval program has been successfully tested on the image set and digital tape for the image 102416511, which covers a portion of southwestern Kansas.

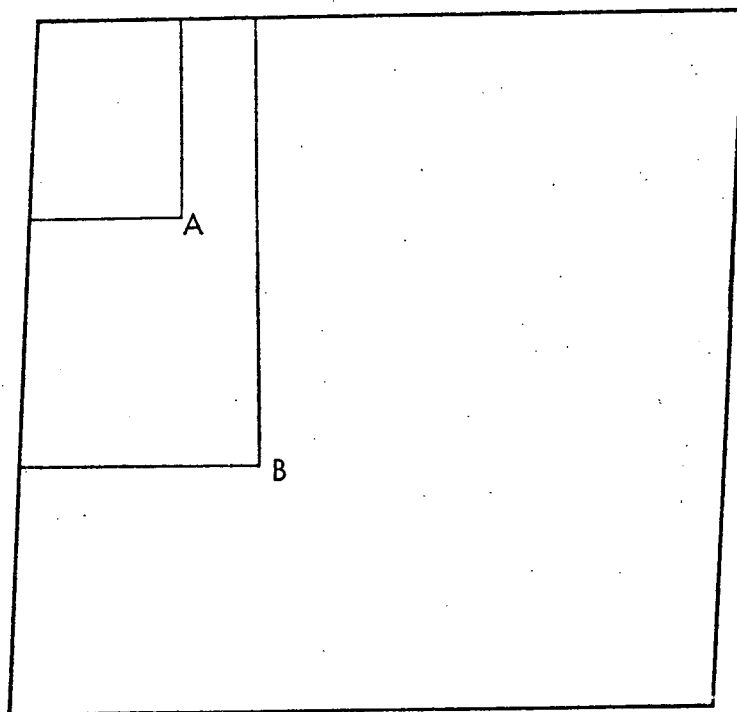Figure 1. Lines within the image area indicate the distances to be measured to determine the approximate digital tape location of two points (A and B).

MONITORING FRESH WATER RESOURCES

Harold Yarger
Remote Sensing Laboratory
Center for Research, Inc.
Space Technology Center
University of Kansas
Lawrence, Kansas 66044

30 November 1972
Bimonthly Report for Period Ending 30 November 1972

5.

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BIMONTHLY ERTS -A INVESTIGATION REPORT

Type I Progress Report
for the period ending: November 30, 1972

NASA Contract NAS 5-21822

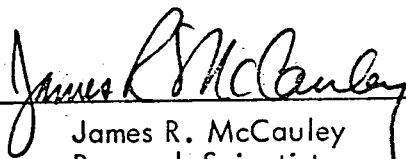Title of Investigation: Monitoring Fresh Water Resources

ERTS-A Proposal Number: 060-7

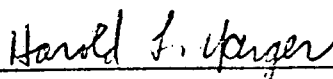Task Number: 5

Principal Investigator: Harold L. Yarger

NASA-GSFC PI ID Number: STO45

Report Prepared by:

James R. McCauley
James R. McCauley
Research Scientist

Report Approved by:

Harold L. Yarger
Harold L . Yarger
Principal Investigator

5-a

I. Summary of research objective(s):

It is the objective of this study to determine the feasibility of monitoring fresh water bodies in Kansas using ERTS-1 imagery. This is to be accomplished by attempting to correlate spectral reflectance with water properties and analyses measured at the time of overflight on two reservoirs under intensive study (Tuttle Creek and Perry Reservoirs).

II. Statement of explanation of problems impeding progress of investigation (i.e., explanation of any nonconformance with work schedule).

We have not received the submarine photometer necessary for turbidity measurement, and are still employing the secchi dish technique; however, these measurements appear to be reasonably accurate. An additional problem, but one fully anticipated, is the freezing of the reservoirs. During the last overflight of Perry Reservoir (November 29th), three sample stations were inaccessible due to ice in the upper end of the lake. Although the reservoirs are expected to freeze completely in January and February, sampling during overflights before and after total freeze will be conducted, the completeness of these sampling missions to be dependent upon ice coverage.

III. Discussion of accomplishments or work performed during reporting period:

Most sampling missions involving $\geq$ ten stations have been conducted successfully on both Perry and Tuttle Creek during the four overflights in this reporting period. The exceptions are the October 6th mission on Perry, which was aborted due to rough water, and the final three stations of the November 29th mission on Perry, which were unattainable due to ice. The following analyses have been performed on the samples for the first three overflights of the period: suspended and dissolved load (organic and inorganic), chlorophyll, nitrate, phosphate and potassium. This is in addition to measurements made in the field, including water temperature and turbidity. Most usable images of Perry and Tuttle Creek reservoirs have been level sliced on IDECS and density measurements corresponding to sample stations are being made to compare with results of sample analyses. All pertinent data, including density measurement and results of sampling missions, are being placed on computer cards for use in the near future.

IV. Discussion of planned accomplishments or work during next reporting period:

A sufficiently large bank of data resulting from sampling missions and water analyses is accumulating to be used with a number of useable ERTS images of Perry and Tuttle Creek in attempts at correlating the spectral signatures of the two reservoirs with observed water properties. These attempts should begin during the next reporting period. In addition, digital tapes have been ordered for one pass over Tuttle Creek and surrounding reservoirs to complement our study of the images and to determine the advantage and disadvantages of such tapes in supplying more reliable data concerning spectral reflectance. Plans are also being made to include sampling of additional reservoirs throughout the state on subsequent overflights. Differences between the appearance of reservoirs on the same image and in the same apparent geologic and landuse regions have been observed and will be studied. In addition, reservoirs in different physiographic provinces and geologic regions will be investigated. This will begin with the next Kansas overflights.

V. Discussion of efforts to achieve reliability:

From the results obtained in level slicing images of the reservoirs and from inspection of results of sample analyses changes have been made in the location of sample stations on both reservoirs. Persistant patterns of gray level variation have been observed on Perry and Tuttle Creek images. The location of old sampling stations failed to document adequately many of these patterns. New sampling stations have been chosen which are spaced more closely in areas of rapid gray level fluction to more control in our ground truth measurements.

Coiner, Currier, and Williams of CRINC are engaged in a related project, the purpose of which is to measure the areal extent of surface water using ERTS images and ultimately to construct surface water maps for various times of the year.

The process is as follows:

1. The IDECS is used to level select the water bodies on an MSS-6 image.

2. A PDP-15 program is called which counts the number of cells which have been selected.

3. By comparison to a known area, the PDP-15 then calculates a total water area.

At present, initial tests with the IDECS have been conducted and areal data can be recovered; however, an error term cannot be assigned at this time. The next step is to

request simultaneous underflights and by conventional means determine the actual area of surficial water for use in comparison with experimental results.

VI. Discussion of significant results and relationship to practical applications or operational problems: NONE .

VII. Discussion and estimates of the cost benefits of any significant results: NONE.

VIII. List of published articles, papers, pre-prints, in-house reports, abstracts of talks that were released during the reporting period after receiving notice of compliance with the provisions of Article IX of the contract: NONE.

IX. Recommendations concerning practical changes in operations, additional investigative effort, correlation of effort and/or results as to maximum utilization of the ERTS system:

From initial comparison of water analyses with density measurements of sample sites on the reservoirs, a favorable correlation has been found between gray level and the amount of suspended solids. Measured ion concentrations, however, have been either very low or lacking correlation with gray-level. As a result, analyses to determine the concentrations of potassium, phosphate and nitrate ions have been dropped. More attention will be given the suspended solids and chlorophyll concentrations and their role in determining the observed spectral signatures.

X. List by date of any changes in the standing order forms: NONE.

XI. Number of ERTS Image Descriptor Forms (Attachment B) as required by Article VII of the contract: attached --three description forms.

XII. List (by date) any Data Request Forms (for retrospective data) submitted to NASA-GSFC/NCPF during the reporting period: November 12 and November 17 copies attached.

XIII. Discussion of adequacy of funds to complete task: Funding is adequate for completion of task.

XIV. Description of any significant changes in operating personnel during the reporting period or anticipated during the next reporting period: NONE.

ERTS IMAGE DESCRIPTOR FORM
(See Instructions on Back)

DATE _Nov. 29, 1972_

PRINCIPAL INVESTIGATOR _H. Yaeger_

GSFC _____

ORGANIZATION _CRINC - K.S.S. Univ. of Kansas_

PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
	LAKE	STREAM	FLOODPLAIN	
1024 - 16511 - 6	"	"	"	SANDHILLS
1021 - 16333 - 4-5-6	"	"	"	
1022 - 16391 - 4-5-6-7	"	"	"	
1022 - 16394 - 6	"	"	"	"
1022 - 16393 - 4-5-6	"	"	"	"
1023 - 16451 - 4-5-6	"	"	"	"
1025 - 16562 - 4-5-6	"	•	"	BADLANDS - OUTCROPS.
1039 - 16332 - 4-5-6	"	"	"	
1039 - 16334 - 4-5-6	"	"	"	
1039 - 16341 - 4-5	• C L	o	u D S	
1056 - 16273 - 4-5	"	"	"	
1057 - 16332 - 4-5-6	"	"	"	
1057 - 16334 - 4-5-6	"	"	"	
1058 - 16380 - 4-5-6	"	"	"	
1058 - 16392 - 4-5-6	"	"	"	
1058 - 16385 - 4-5-6	"	"	"	SALT FLATS
1060 - 16505 - 4-5-6	"	"	"	OUTCROPS
1060 - 16512 - 4-5-6	"	"	"	
1074 - 16280 - 4-5-6	C L o	u	D S	
1074 - 16273 - 4-5-6-7	C L o	u	D S	
1074 - 16282 - 4-5-6-7	C L o	u	D S	

*FOR DESCRIPTORS WHICH WILL OCCUR FREQUENTLY, WRITE THE DESCRIPTOR TERMS IN THESE COLUMN HEADING SPACES NOW AND USE A CHECK (✓) MARK IN THE APPROPRIATE PRODUCT ID LINES. (FOR OTHER DESCRIPTORS, WRITE THE TERM UNDER THE DESCRIPTORS COLUMN).

MAIL TO   ERTS USER SERVICES
            CODE 563
            BLDG 23 ROOM E413
            NASA GSFC
            GREENBELT, MD. 20771
            301-982-5406

ERTS IMAGE DESCRIPTOR FORM
(See Instructions on Back)

DATE _Nov. 21 1972_

PRINCIPAL INVESTIGATOR _H. Yarger_

GSFC _____

ORGANIZATION _CR112 - K.G.S - Univ. OF KANSAS_

PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
	LAKE	_STREAM_	_FLOODPLAIN_	
1075 - 16332 - 4-5-6-7	C	L O U	D S	
1075 - 16333 - 4-5-6-7	C	L O U	D S	
1075 - 16341 - 4-5-6-7	C	L O U	D S	
1076 - 16391 - 4-5-6-7		"	"	
1076 - 16393 - 4-5-6-7	"	..	..	
1076 - 16400 4-5-6-7	"	..	"	SAND HILLS
1077 - 16445 - 4-5-6-7	C	L O U	D S	
1077 - 16452 - 4-5-6-7	C	L O U	D S	
1077 - 16454 - 4-5-6-7	"	..	..	SAND HILLS
1078 - 16509 - 4-5-6-7	C	L O U	D S	
1078 - 16510 - 4-5-6	C	L O U	D S	
1078 - 16513 - 4-5-6-7	C L	O U	D S	
1079 - 16562 - 4-5-6-7	C L	O U	D S	
1079 - 16565 - 4-5-6-7	C L	O U	D S	
~~1079~~ 1092 - 16285 - 4-5-7	C L	O U	D S	
1093 - 16344 - 4-5-6	C L	O U	D S	
1094 - 16395 - 4-5-6-7	"	"	"	
1094 - 16402 - 4-5-6-7	..	..	..	SALT FLATS
1095 - 16460 - 4-5-7	"	..	..	SALT MARSH

*FOR DESCRIPTORS WHICH WILL OCCUR FREQUENTLY, WRITE THE DESCRIPTOR TERMS IN THESE COLUMN HEADING SPACES NOW AND USE A CHECK (✓) MARK IN THE APPROPRIATE PRODUCT ID LINES. (FOR OTHER DESCRIPTORS, WRITE THE TERM UNDER THE DESCRIPTORS COLUMN).

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NASA GSFC
GREENBELT, MD. 20771
301-982-5406

GSFC 37-2 (7/72)

5-5

ERTS IMAGE DESCRIPTOR FORM
(See Instructions on Back)

DATE _NOV. 29_

PRINCIPAL INVESTIGATOR _H. YARGER_

GSFC _____

ORGANIZATION _CRINC- KGS- UNIV. OF KANSAS_

PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
	LAKE	_STREAM_	_FLOODPLAIN_	
1096 · 16510 - 4-5-6-7	..	..	..	
1096 - 16512 - 4-5-6-7	..	..	..	
1096 - 16515 - 4-5-6-7	C L O U	D S		

*FOR DESCRIPTORS WHICH WILL OCCUR FREQUENTLY, WRITE THE DESCRIPTOR TERMS IN THESE COLUMN HEADING SPACES NOW AND USE A CHECK (✓) MARK IN THE APPROPRIATE PRODUCT ID LINES. (FOR OTHER DESCRIPTORS, WRITE THE TERM UNDER THE DESCRIPTORS COLUMN).

MAIL TO   ERTS USER SERVICES
CODE 563
BLDG 23   ROOM E413
NASA GSFC
GREENBELT, MD. 20771
301-982-5406

GSFC 37-2 (7/72)

1. DATE ___Nov. 12___

2. USER ID ___STO 45___

   H. L. YARGER

4. SHIP TO:

   ADDRESS ___JIM McCAULEY___ ☐
   NEW

   ___CENTER FOR RESEARCH___

   ___UNIV. OF KANSAS___

   ___LAWRENCE, KANSAS 66044___

5. TELEPHONE NO. ___913-864-4014___ ☐
   NEW

6. CATALOGUES DESIRED

   STANDARD ☑ U.S. ☐ NON-U.S.

   DCS ☐

   MICROFILM ☐ U.S. ☐ NON-U.S.

ADDDHHMMS OBSERVATION IDENTIFIER	C CENTER POINT COORDINATES	B SENSOR BAND	P PRODUCT TYPE	F PRODUCT FORMAT	T TICK MARKS	NN NUMBER OF COPIES	A AREA
1022·16391	31° 19' 86° 45'	M	D	7		1	U

ERTS DATA REQUEST FORM
560-213 (7/72)

1. DATE _Nov. 17 1972_

2. USER ID _ST095_

    H.L. YARGER

4. SHIP TO:

    ADDRESS _JIM McCAULEY_ ☐

    CENTER FOR RESEARCH NEW

    UNIV, OF KANSAS

    LAWRENCE, KANSAS 66044

5. TELEPHONE NO. _913-869-4832_ ☐ NEW

6. CATALOGUES DESIRED

    STANDARD ⬚U.S. ☐ NON-U.S.

    DCS ☐

    MICROFILM ☐ U.S. ☐ NON-U.S.

ADDDHHMMS OBSERVATION IDENTIFIER	C CENTER POINT COORDINATES	B SENSOR BAND	P PRODUCT TYPE	F PRODUCT FORMAT	T TICK MARKS	NN NUMBER OF COPIES	A AREA
1022-16391	39°19' 96°45'	M		T		1	U.S.
1058-16392	38°54' 96°54'	4		T		1	"
" "	" "	5		"		1	"
" "	" "	6		"		1	"
1076-16393	38°56' 96°53'	M		T		1	"

5-8

Data Analysis Plan

November 30, 1972

NASA Contract NAS5-21822

Title of Investigation: Monitoring Fresh Water Resources

ERTS-A Proposal No.: 060-7

Principal Investigator: Harold L. Yarger (ST045)

Our data analysis plan, based on the first two month's imagery, remains essentially unchanged. We do plan, however, to make the following modification.

To date 10 samples each from Perry and Tuttle Creek reservoirs, every 18 days, have been analyzed for suspended solids (inorganic), suspended solids (organic), dissolved solids (inorganic), dissolved solids (organic), chlorophyll, nitrate ions, phosphate ions, and potassium ions. We plan to increase the number of samples by sampling other reservoirs in addition to Perry and Tuttle Creek and/or increasing the number of samples at Perry and Tuttle Creek. To create enough additional manhours for analyzing additional samples, the chlorophyll and ion analyses (nitrate, phosphate, and potassium) will not be done on all samples. The ion analyses will be done on one or two samples/reservoir. The chlorophyll analysis will be done on approximately 50 percent of the samples. In other words, the manhours required for increased solids analyses will be offset by a reduction of manhours required for chemical analyses resulting in no change in budget requirements.

This change is justified by the fact that film density from imagery received so far shows a strong qualitative correlation with concentration of solids and no apparent correlation with the measured chemical concentrations. Increasing the number of solids measurements will enhance the possibility of developing a quantitative relation between film density and solids concentration.

GROUND PATTERN ANALYSIS IN THE GREAT PLAINS

Fawwaz T. Ulaby
Remote Sensing Laboratory
Center for Research, Inc.
Space Technology Center
University of Kansas
Lawrence, Kansas 66044

30 November 1972
Bimonthly Report for Period Ending 30 November 1972

6 - a

BIMONTHLY ERTS-A USER INVESTIGATION REPORT

Type I Progress Report
for the period ending: November 30, 1972

NASA Contract NAS 5-21822

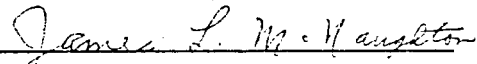Title of Investigation: Gound Pattern Analysis in the Great Plains
ERTS-A Proposal Number: 60-8
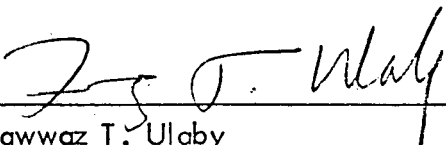Task Number: 6
Co-principal Investigators: John C. Davis, Fawwaz T. Ulaby
NASA-GSFC PI ID Number: UN 657

Report Prepared by:

James L. McNaughton
Project Engineer

Report Approved by:

Fawwaz T. Ulaby
Co-principal Investigator

6 6

I. RESEARCH OBJECTIVES

The two program objectives of this study may be defined as:

A. Use of multispectral imagery to map the areal geology of selected sites in Kansas, and to identify anomalous patterns.

B. Search for large-scale ground patterns by spatial frequency analysis.

II. PROBLEMS

Images 1003-16341-2, 1003-16350-2, 1006-16502-2, 1006-16504-2, 1006-16511-2, 1007-16563, 1007-16560-2, have been received, however, the images ordered from the other bands on a Data Request Form dated 12 September 1972, have not been received. As soon as we receive these images we will begin our multispectral studies.

III. WORK PERFORMED DURING THIS REPORT PERIOD.

During this report period, the manual interpretation of the usable images from ERTS has continued. We are still in the process of experimenting with system parameters associated with our optical processing system. System parameters to be optimized include the scale factor (factor relating the spatial frequency scale of the Fourier transform to the image ground scale), sample size (size of sample area on image being transformed), and the interrelation of these factors with ground resolution.

The optical processing system, which includes the laser, optics and a Recognition Systems Inc. Diffraction Pattern Sampling Unit (DPSU), is used in the spatial frequency analysis of our imagery. Using the ERTS images as the input to our system, the Fourier transform of the specific sample area is obtained optically and detected by the DPSU.

The DPSU consists of a diode array used to detect the intensity distribution across it, and electronics which amplify and digitize the output from each diode on the array. The diode array is composed of 32 wedge-shaped photodiodes and 32 annular ring photodiodes. Therefore the output from any element is related to the light intensity integrated over the area of that element. The output from our array,

then, may be used to characterize ground features indirectly in terms of intensity versus radius or angle on the detector array.

IV. PLANNED WORK NEXT REPORT PERIOD

Spatial frequency analysis of ERTS imagery and optical processor system parameter studies will continue during the next report period. Output from the spatial frequency analysis will be compared to detect similarities or trends in the intensity distribution of the Fourier transforms. Detection of trends or similarities in the Fourier transform intensity distributions will be an indicator of trends, patterns, or similarities in the original ERTS images. Also we will relate the Fourier transform intensity distribution patterns to ground features and search for any anomalous features that might be contained in the images.

V. RELIABILITY EFFORTS

We have encountered several problems in obtaining reliable digitized Fourier transform intensity distributions with our optical processing system. The problems have been traced to a combination of equipment instability and procedural variations. However, these problems are being corrected and they are not a significant deterrent to the progress in this investigation.

VI. SIGNIFICANT RESULTS

None

VII. COST BENEFITS OF SIGNIFICANT RESULTS

None

VIII. PUBLISHED PAPERS, ARTICLES, REPORTS

None

IX. RECOMMENDATIONS REGARDING MAXIMUM UTILIZATION OF ERTS SYSTEM

None

X. CHANGES IN STANDING ORDER FORMS

None

XI. ERTS IMAGE DESCRIPTOR FORMS (Attachment B)

Attached

XII. DATA REQUEST FORMS SUBMITTED

12 September 1972   (as reported in progress report dated 30 September 1972)

XIII. FUNDING

Funding is adequate.

XIV. CHANGE IN PERSONNEL

The project engineer for this investigation, Mr. Dwight Egbert, will be taking a three month leave of absence starting in January 1973. Mr. J. McNaughton, an engineer who was added to project personnel in October 1972, will

be replacing him during this period. After Mr. Egbert's return, both engineers
will continue to be involved in this study.

ERTS IMAGE DESCRIPTOR FORM
(See Instructions on Back)

DATE __November 30, 1972__

PRINCIPAL INVESTIGATOR __John C. Davis and Fawwaz T. Ulaby__

GSFC __UN 657__

ORGANIZATION __University of Kansas Center for Research, Inc.__

PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
	Stream	Lake	Floodplain	
1020-16273-4,5	"	"	"	DENDRITIC DRAINAGE
1020-16275-4,5	"	"	"	" "
1020-16282-4,5	"	"	"	" "
1021-16342-4,5	"	"	"	" "
1026-17024-4,5	"	"	"	SANDHILLS
1057-16341-4,5	"	"	"	DENDRITIC DRAINAGE
1061-16561-4,5	"	"	"	PARALLEL DRAINAGE
1061-16564-4,5	"	"	"	PARALLEL DRAINAGE + OUTCROPS
1061-16570-4,5	"	"	"	SANDHILLS
1062-17015-4,5	"			
1062-17022-4,5	"			
1098-17025-4,5	"			

*FOR DESCRIPTORS WHICH WILL OCCUR FREQUENTLY, WRITE THE DESCRIPTOR TERMS IN THESE COLUMN HEADING SPACES NOW AND USE A CHECK (✓) MARK IN THE APPROPRIATE PRODUCT ID LINES. (FOR OTHER DESCRIPTORS, WRITE THE TERM UNDER THE DESCRIPTORS COLUMN).

MAIL TO   ERTS USER SERVICES
            CODE 563
            BLDG 23 ROOM E413
            NASA GSFC
            GREENBELT, MD. 20771
            301-982-5406

GSFC 37-2 (7/72)

INSTRUCTIONS FOR COMPLETION OF IMAGE DESCRIPTOR FORM GSFC 37-2 (7/72)

Image descriptors are only supplied by investigators. An image descriptor is a term which assists in defining the content of an image. All of these inputs will be compiled and entered into the NDPF data base for subsequent investigator query servicing and catalog preparation. A standard vocabulary of image descriptors is included in the Data Users Handbook, Section 4.

Coding for the major portion of this form is straight forward and self explanatory. It should be noted however that it is extremely important to assign the correct product ID to those descriptors that apply to a particular spectral image or a combination of spectral images. Below is a description of the product ID along with tables defining the valid band and product type (processing designator). Your cooperation in providing complete, valid product ID's would be greatly appreciated.

SATELLITE NUMBER (1 = ERTS A; 2 = ERTS B)

DAYS SINCE LAUNCH

HOUR OF DAY (GMT)

MINUTES OF HOUR (GMT)

TENS OF SECONDS OF MINUTES (GMT)

PRODUCT ID

A	D	D	D	H	H	M	M	S	B	P
1	0	3	7	0	5	1	8	5	X	B

"B" CODE SENSOR SPECTRAL BAND DESIGNATOR

B	Band
1	RBV 1
2	RBV 2
3	RBV 3
4	MSS 1
5	MSS 2
6	MSS 3
7	MSS 4
R	All RBV Bands
M	All MSS Bands
X	All Bands

"P" CODE PROCESSING DESIGNATOR (PRODUCT)

P	Processing Type
Blank	Sys. Corr.
A	Scene Corr.
B	Sys. Corr. Color
C	Scene Corr. Color
D	Sys. Corr. Digital
E	Scene Corr. Digital
X	Non Standard Processing

Sys. Corr. – System Corrected Images (Bulk)

Scene Corr. – Scene Corrected Images (Precision)

ERTS IMAGE DESCRIPTOR FORM
(See Instructions on Back)

DATE ___ November 30, 1972 _____

PRINCIPAL INVESTIGATOR ___ John C. Davis and Fawwaz T. Ulaby ___

GSFC ___ UN 657 _____

ORGANIZATION ___ University of Kansas Centerfor Research, Inc. ___

PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
	Lake	Stream	Floodplain	
1021-16333-4,5	"	"	"	
1023-16451-4,5	"	"	"	SANDHILLS
1056-16273-4,5	"	"	"	
1057-16332-4,5	"	"	"	
1057-16334-4,5	"	"	"	
1076-16391-4,5	"	"	"	
1076-16393-4,5	"	"	"	
1076-16400-4,5	"	"	"	SANDHILLS
1077-16454-4,5	"	"	"	SANDHILLS

*FOR DESCRIPTORS WHICH WILL OCCUR FREQUENTLY, WRITE THE DESCRIPTOR TERMS IN THESE COLUMN HEADING SPACES NOW AND USE A CHECK (✓) MARK IN THE APPROPRIATE PRODUCT ID LINES. (FOR OTHER DESCRIPTORS, WRITE THE TERM UNDER THE DESCRIPTORS COLUMN).

MAIL TO   ERTS USER SERVICES
CODE 563
BLDG 23 ROOM E413
NASA GSFC
GREENBELT, MD. 20771
301-982-5406

INSTRUCTIONS FOR COMPLETION OF IMAGE DESCRIPTOR FORM GSFC 37-2 (7/72)

Image descriptors are only supplied by investigators. An image descriptor is a term which assists in defining the content of an image. All of these inputs will be compiled and entered into the NDPF data base for subsequent investigator query servicing and catalog preparation. A standard vocabulary of image descriptors is included in the Data Users Handbook, Section 4.

Coding for the major portion of this form is straight forward and self explanatory. It should be noted however that it is extremely important to assign the correct product ID to those descriptors that apply to a particular spectral image or a combination of spectral images. Below is a description of the product ID along with tables defining the valid band and product type (processing designator). Your cooperation in providing complete, valid product ID's would be greatly appreciated.

SATELLITE NUMBER (1 = ERTS A; 2 = ERTS B)

DAYS SINCE LAUNCH

HOUR OF DAY (GMT)

MINUTES OF HOUR (GMT)

TENS OF SECONDS OF MINUTES (GMT)

PRODUCT ID

A	D	D	D	H	H	M	M	S	B	P
1	0	3	7	0	5	1	8	5	X	B

"B" CODE SENSOR SPECTRAL BAND DESIGNATOR

B	Band
1	RBV 1
2	RBV 2
3	RBV 3
4	MSS 1
5	MSS 2
6	MSS 3
7	MSS 4
R	All RBV Bands
M	All MSS Bands
X	All Bands

"P" CODE PROCESSING DESIGNATOR (PRODUCT)

P	Processing Type
Blank	Sys. Corr.
A	Scene Corr.
B	Sys. Corr. Color
C	Scene Corr. Color
D	Sys. Corr. Digital
E	Scene Corr. Digital
X	Non Standard Processing

Sys. Corr. – System Corrected Images (Bulk)

Scene Corr. – Scene Corrected Images (Precision)

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